GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester-IV

Course Title: DC Power Electronic Converters & Drives
(Course Code: 4342401)

Diploma programmer in which this course is offered	Semester in which offered
Power Electronics	4th semester

1. RATIONALE

The most important application of power electronics is speed control of DC motor in industries, vehicles and renewable energy. So this course is mainly related with selection and speed control of DC motor drives used in various applications. This course attempts to develop skills in operation and maintenance of power rectification, controlled rectifiers and choppers related to conversion of DC to DC power used for applications of power control in industries for DC drives.

2. COMPETENCY

The purpose of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Operate and Maintain DC Power Electronic Converters & Drives.**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with this competency are to be developed in the student to display the following COs:

CO 1) Select a proper DC motor for DC Drive as per their load characteristics.
CO 2) Maintain 1-Phase Controlled converters and Drives.
CO 3) Maintain 3-Phase Controlled converters and Drives.
CO 4) Maintain Chopper Drives.
CO 5) Operate DC Drives in breaking mode.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
4	-	2	5	30*	70	25	25	150

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

***Legends: L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** -Practical; **C** – Credit, **CA** - Continuous Assessment; **ESE** -End Semester Examination.*

5. SUGGESTED PRACTICAL EXERCISES

*Following practical outcomes (PrOs) that are the sub-components of the Course Outcomes (Cos). Some of the **PrOs** marked **'*'** are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'.*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1.	Test 1-Ø half wave controlled converter with R and RL load.		4*
2.	Select motor for given specific application	I	2*
3.	Test the various DC Motors.	I	2
4.	Test 1-Ø half wave full controlled converter (semi converter) with R and RL load.	II	2
5.	Test 1-Ø full wave fully controlled converter with R and RL load.	II	2*
6.	Test parallel dual converter with R load	II	2
7.	Study of controlled rectifier circuit and its gate pulse generation mechanism.	II	2*
8.	Study Open-loop control of Separately Exited DC Motor.	II	2*
9.	Measurement of speed of Separately Exited DC Motor with speed sensor feedback	II	2*
10.	Control the speed of DC motor using dual converter	II	2*
11.	Test 3-Ø, three pulse, half wave controlled converter with R load	III	2
12.	Test 3-Ø semi converter with R load	III	2
13.	Test 3-Ø Fully controlled with R load	III	2
14.	Control the speed of DC motor using 3-Ø half wave controlled converter.	III	2*
15.	Control the speed of DC motor using 3-Ø semi converter.	III	2*
16.	Control the speed of DC motor using 3-Ø fully controlled converter.	III	2*
17.	Test buck converter.	III	2
18.	Test boost converter.	III	2
19.	Test buck boost converter.	III	2
20.	Study of four quadrant chopper circuit with its gate-pulses generation mechanism.	IV	2*
21.	Study Bidirectional control of Separately Exited DC Motor (CW/CCW switching pattern).	IV	2*
22.	Measurement of speed of SEDC Motor with speed sensor feedback	IV	2*
23.	Perform Speed control using Regenerative/dynamic/ counter current breaking.	V	4*
	Minimum 14 Practical Exercises		**28* Hrs.**

Note

i. *More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.*

ii. *The following are some **sample** 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency.*

S. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Prepare of experimental setup	20

S. No.	Sample Performance Indicators for the PrOs	Weightage in %
2	Operate the equipment setup or circuit	20
3	Follow safe practices measures	10
4	Record observations correctly	20
5	Interpret the result and conclude	30
Total		**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

These major equipments with broad specifications for the PrOs is a guide to procure them by the administrators to user in uniformity of practical's in all institutions across the state.

S. No.	Equipment Name with Broad Specifications	PrO.No.
1	**Microcontroller Based Chopper Fed Separately Excited DC Motor Drive:** Specification: The kit comprise of a 0.5HP, 180V, 1500RPM SEDC motor, control module consist of IGBT H-Bridge to drive the DC motor with proximity sensor as speed sensor and microcontroller based digital control circuit. Microcontroller based control circuit with LCD and keyboard interface is provided for selecting different operating modes. Observation of intermediate stage waveforms of gate pulse generation. Open loop and closed loop speed control of motor. MATLAB utility for viewing and controlling speed of the motor from personal computer. The kit works directly with 230 V, 50 Hz, AC supply. Proper isolation between control and power circuit is provided. Motor Controller: SST89E516RD 8-bit MCU clocked @18.432MHz Buffered I/O Ports using 74HC573 5 Interface Keys 16x2 LCD (JHD162A) display UART section (IC Max 232)	20,21,22
2	**Microcontroller Based Control Rectifier Fed Separately Excited DC Motor Drive trainer:** SST89E516RD 8-bit MCU clocked @18.432MHz Buffered I/O Ports using 74HC573 5 Interface Keys 16x2 LCD (JHD162A) display UART section (IC Max 232)	7,8,9
3	**Microcontroller Based dual converter FED SEDC Motor Drive:** SST89E516RD 8-bit MCU clocked @18.432MHz Buffered I/O Ports using 74HC573 5 Interface Keys 16x2 LCD (JHD162A) display UART section (IC Max 232) Rating 300V, 5A SCR 25TT12 (25A, 1200V) Diode 1N5408 (4 Nos.) Snubber circuit	6,10
4	**High voltage Power Electronics Lab** Technical Specifications MCB (Power Switch) : Single Phase 10A MCB (Power Switch) : Three Phase 10A Single Phase AC Power Supply : 230V, ± 10%, 50Hz 115V - 0 - 115V ± 10%, 2A Single Phase Low Voltage AC Power Supply: 18V - 0 - 18V, 15V-0 Low Voltage DC Power Supply : +30V, -30V 250mA : +15V, -15V 250mA : +12V, -12V 500mA : +5V, -5V 500mA Three Phase AC Power Supply : 230V Phase voltage ± 10% 50Hz 440 Line voltage ± 10% 50Hz Three Phase Low Voltage : 15V Each Phase ± 10%, 50Hz Power Supply Interconnections : 2mm & 4mm Safety Socket Diode Assembly : Diode 6A10 1000V/6A SCR Assembly : TYN 616 600V/16A IGBT Assembly : IGBT G4BC20S 600V/10A Gate Firing Circuits Single Phase Firing Circuit : Ramp Comparator Firing Circuit 0 (Firing Angle Control 30-180) Three Phase Firing Circuit : Three Phase Firing Circuit 0 (Firing Angle Control 30-150) Cycloconverter Firing Circuit : Cycloconverter Firing Circuit 0 (Firing Angle Control 30-180) Single Phase and Three Phase Inverter firing circuit : Firing Pulse - 50Hz Square Wave with 10Vpp	4,5,17,18,19

7. AFFECTIVE DOMAIN OUTCOMES

The following ***sample*** Affective Domain Outcomes (ADOs) are embedded in many of the above mentioned COs and PrOs. More could be added to fulfill the development of this competency.

a) Work as a leader/a team member.
b) Follow error free measurement rules during measurement.
c) Practice environmentally friendly methods and processes.(Environment related)

The ADOs are best developed through the laboratory/field based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

i. 'Valuing Level' in 1st year
ii. 'Organization Level' in 2nd year.
iii. 'Characterization Level' in 3rd year.

8. UNDERPINNING THEORY

Only the major Underpinning Theory is formulated as higher level UOs of *Revised Bloom's taxonomy* in order development of the COs and competency is not missed out by the students and teachers. If required, more such higher level UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at Application and above level)	Topics and Sub-topics
Unit – I Characteristics of DC Motors and Dynamics of Electric Drives.	1.a Explain Characteristics of separately exited DC motor.	1.1 Separately exited DC motor: • Equivalent circuit and basic equations. • Basic characteristics for constant torque and constant power drive.
	1.b Explain Characteristics of DC Shunt motor.	1.2 DC Shunt Motor: • Equivalent circuit, Equations. • Basic Characteristics of speed current, torque current, speed torque. • Modifications to the Speed-Torque Characteristic of a dc Shunt Motor.
	1.c Explain Characteristics of DC series motor	1.3 DC series motor: • Equivalent circuit, equations and basic characteristics, Effect of Variation of Armature Voltage, Field Weakening. • Desirable Modifications of the Speed-Torque Characteristic of Series Motors.
	1.d Speed-Torque Characteristics of Compound Motors	1.4 Compound motor: Speed current, torque current and speed to torque Characteristics of cumulative and differential compound DC motor.
	1.e Explain speed control of separately exited DC motor.	1.5 Speed control of separately exited DC motor:

Unit	Unit Outcomes (UOs) (4 to 6 UOs at Application and above level)	Topics and Sub-topics
		• By adding resistance in armature circuit. • By adjusting armature voltage. • By adjusting field voltage.
	1.f Explain speed control of DC series motor.	1.6 Speed control of DC series motor • By adding resistance in armature circuit. • By adjusting armature voltage. • By adjusting field current.
	1.g Explain concept of electric drive.	1.7 Electric drive: Concept, block diagram, Basic Elements and advantages.
	1.h Explain Load Torques.	1.8 Load Torques: • Load torques that depends on the path or position taken by the load during motion. • Load torques that varies with angle of displacement of the shaft. • Load torques that varies with time.
	1.i Explain four quadrant Electric drive system	1.9 Four quadrant drives with examples.
	1.j Explain dynamic conditions of a drive system. 1.k Explain stability considerations of electrical drives.	1.10 Dynamic conditions of Electric Drive. 1.11 Steady state and transient stability of electrical drives.
Unit– II **1 – Ø Controlled converters and Drives.**	2.a Explain 1-Ø half wave controlled converter. 2.b Explain 1-Ø Half-wave converter Drives.	2.1 Half wave controlled converter with R load, RL load (with and without freewheeling diode). 2.2 1-Ø Half-wave converter drive for Separately Exited D.C. Motor.
	2.c Explain 1-Ø full wave half-controlled bridge converter (semi converter). 2.3 Explain 1-Ø Semi converter Drives.	2.4 Half Controlled bridge converter with R load, RL Load (with and without freewheeling diode). 2.5 1-Ø Semi converter Drive with continuous armature current for Separately Exited D.C. Motor.
	2.d Explain 1-Ø Full wave controlled converter. 2.e Explain 1-Ø Full converter Drives.	2.6 Full wave Controlled converter: Bridge Converter with R and RL Load. 2.7 1-Ø Full converter Drives with continuous armature current for Separately Exited D.C. Motor.
	2.f Explain 1-Ø Dual Converter. 2.g Explain 1-Ø Dual Converter drives.	2.8 Dual converter: analysis and applications. 2.9 1-Ø Dual Converter drives for Separately Exited D.C. Motor.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at Application and above level)	Topics and Sub-topics
Unit – III **3– Ø Controlled converters and Drives.**	3.a Explain 3-Ø Half wave controlled Converter. 3.b Explain 3-Ø Half wave Converter drives.	3.1 3-Ø half wave controlled converter (M_3 connection) with R Load. 3.2 3-Ø Half wave converter drives with separately exited DC Motor.
	3.c Explain 3-Ø Semi Converter. 3.d Explain 3-Ø Semi Converter Drives.	3.3 3-Ø semi converter with R Load. 3.4 Explain 3-Ø Semi Converter Drives with separately exited DC Motor.
	3.e Explain 3-Ø fully controlled bridge Converter. 3.f Explain 3-Ø fully controlled Converter drives.	3.5 Explain 3-Ø fully controlled bridge Converter with R Load. 3.6 3-Ø Full Converter drives with separately exited DC Motor.
Unit – IV **DC Chopper Drives**	4.b Classify DC Chopper.	4.1 Classification of chopper according to voltage, direction of output voltage and current, according to commutation method.
	4.c Explain principle of Step down, Step-up and Step up-down Chopper. 4.d Explain Control strategies of chopper	4.2 Basic Principle: Step down, Step-up and Step up-down Chopper. 4.3 Control strategies: Time Ratio and Current Limit Control.
	4.e Explain First Quadrant, Two Quadrant and Four Quadrant chopper.	4.4 Chopper circuits: • First quadrant OR type-A chopper. • Second quadrant OR type-B chopper. • Two quadrant type A OR type-C chopper. • Two quadrant type B OR Type D chopper • Four quadrant OR Type E chopper.
	4.f Explain Chopper Drives.	4.5 Control modes: Power control, Regenerative breaking control, two quadrant Chopper Drives and Four quadrant chopper drives.
Unit– V **Breaking, Rating and Heating of motor.**	5.a Explain the breaking of electric motor. 5.b Explain Characteristics of DC motor during Breaking.	5.1 Breaking: Types, Comparison, Methods of Electric Braking of Electric Motors. 5.2 Breaking of DC motor: • Regenerative breaking for shunt and series motors. • Dynamic Breaking for shunt and series motors. • Counter current Breaking for shunt and series motors.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at Application and above level)	Topics and Sub-topics
	5.c Explain Power loss and Heating of Electric motors.	5.3 Power loss and Heating.
	5.d Classify classes of insulating materials and permissible temperatures.	5.4 Classify classes with material with temperature.
	5.e Explain classis of duty and selection of motor.	5.5 Modes of duties: Continuous duty, Short time duty, intermittent load cycle.

***Note**: The UOs need to be formulated at an 'Application Level' and above of Revised Bloom's Taxonomy' to accelerate the attainment of the COs and the competency.*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I.	**Characteristics of DC Motors and Dynamics of Electric Drives.**	**08**	**4**	**8**	**0**	**12**
II.	**1 – Ø Controlled converters and Drives.**	**14**	**4**	**8**	**6**	**18**
III.	**3– Ø Controlled converters and Drives.**	**10**	**2**	**6**	**4**	**12**
IV.	**DC Chopper Drives**	**16**	**6**	**8**	**6**	**20**
V.	**Breaking, Rating and Heating of motor.**	**08**	**2**	**6**	**0**	**08**
Total		**56**	**18**	**36**	**16**	**70**

***Legends:** R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*

***Note**: This specification table provides general guidelines to assist student for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary slightly from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a) **Make a chart of characteristics of Various DC motors.**
b) **Interpret the various parameters by reading Name plate of DC motor.**
c) **Make a chart of classes of insulating materials used in Electric motor.**
d) **Make a chart of applications of Various DC motor Drives as per application.**

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b) Guide student(s) in undertaking micro-projects.
c) ***'L' in section No. 4***means different types of teaching methods that are to be employed by teachers to develop the outcomes.
d) About ***20% of the topics/sub-topics*** which are relatively simpler or descriptive in nature is to be given to the students for ***self-learning***, but to be assessed using different assessment methods.
e) With respect to ***section No.11***, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
f) Guide students for reading a datasheet of power electronic switches used for DC drives.
g) Guide students for selecting proper DC power electronic converters for the speed control of DC motor.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project is group-based (group of 3 to 5). However, **in the fifth and sixth semesters**, the number of students in the group should **not exceed three**.

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The duration of the micro-project should be about **14-16 (fourteen to sixteen) student engagement hours** during the course. The students ought to submit micro-project by the end of the semester to develop the industry-oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

a) Make a Presentation for characteristics of various DC motors.
b) Make a presentation of various 1-Phase/3-Phase/Chopper Controlled DC motor drives.
c) Design a basic 1-phase/Chopper Drive circuit.

13. SUGGESTED LEARNING RESOURCES:

S. No.	Title of Book	Author	Publication with place, year and ISBN
1	Electric Drives concepts and applications.	Vedam Subrahmanyam	TMH ISBN: 9780070701991
2	A First Course on Electrical Drives	S.K.Pillai	NEW AGE ISBN:9788122433616
3	Power Electronics	P.S.Bimbhra	KHANNA ISBN: 9788174092793
4	Power Electronics	M Singh, K Khanchandani	TMH ISBN:9780070583894

14. SOFTWARE/LEARNING WEBSITES

a) https://www.vlab.co.in
b) https://nptel.ac.in
c) https://www.classcentral.com
d) https://swayam.gov.in/
e) https://shodhganga.inflibnet.ac.in/
f) https://onlinecourses.nptel.ac.in/

15. PO-COMPETENCY-CO MAPPING

Semester IV	DC Power Electronic Converters & Drives (4342401)						
	POs and PSOs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solutions	PO 4 Engineering Tools, Experimentation &Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning
Competency	Operate and Maintain DC Power Electronic Converters & Drives.						
CO 1) Characteristics of DC Motors and Dynamics of Electric Drives	2	1	-	1	-	1	2
CO 2) 1 – Ø Controlled converters and Drives.	2	2	3	3	2	2	3
CO 3) 3– Ø Controlled converters and Drives	2	2	2	2	2	2	3
CO 4) Chopper Drives	2	2	3	3	2	2	3
CO 5) Breaking, Rating and Heating of motor	1	1	1	1	-	1	2

Legend: '**3**' for high, '**2**' for medium, '**1**' for low or '**-**' for the relevant correlation ofeach competency, CO, with PO/ PSO

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

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1.	Mr. Vinod N. Makwana Lecturer – Power Electronics Department.	Dr. S. & S. S. Ghandhy college of engineering & Technology, Surat	9427386784	vinodmakwana1@rediffmail.com
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